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Power Coupler Development for RIA

Spoke Cavity Workshop - Los Alamos National Lab
October 7-8, 2002
Brian Rusnak

Proposed RIA Window/Coupler Design Philosophy

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- Mechanical - even a modest coupler needs to be reliable
  - Use common components and geometries to reduce costs
  - Use brazed ceramic windows, Conflats, and VCR fittings over indium wire
  - Design for a warm window to avoid a secondary gas barrier
- RF/Electrical - becomes important if coupler size gets quite small
  - Avoid bellows in RF transmission line to narrow MP resonance bands
  - Design voltage handling of coupler geometry to handle 100% of the full standing wave power levels anticipated for an infinite VSWR condition (4x travelling wave power)
- Thermal - this is a CW coupler
  - Design with a thermal margin of ~200% at nominal operating VSWR
  - Use conductive cooling to thermal intercept circuit where possible to simplify design

RIA Power Coupler Requirements are Tied to Microphonic and RF Architecture Issues

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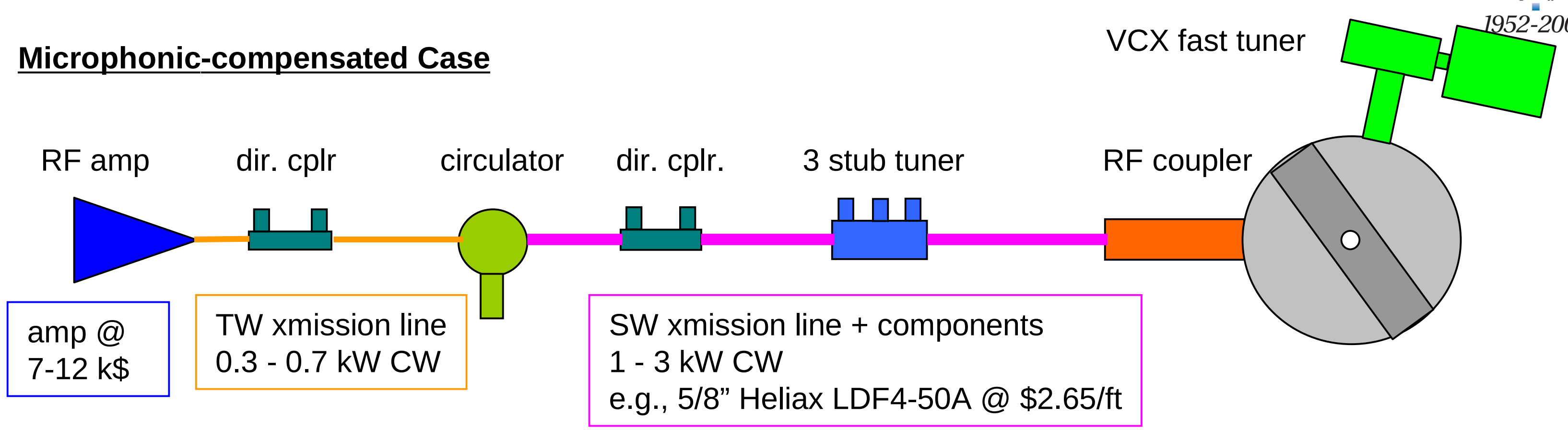
	numbers needed	frequency range	CW travelling wave (W)	CW standing wave (W)	operating VSWR	coupling approach
compenated micorphonics						
low β driver	276	57.5 - 345 MHz	350 - 700	1,400 - 3,000	1.7	magnetic
high β driver	140	805	2,000 - 6,000	8,000 - 24,000	1.5	electric
overcoupled approach						
low β driver	276	57.5 - 345 MHz	1,000 - 3,000	4,000 - 12,000	5 - 22	magnetic
high β driver	140	805	12,000 - 25,000	48,000 - 100,000	16 - 20	electric

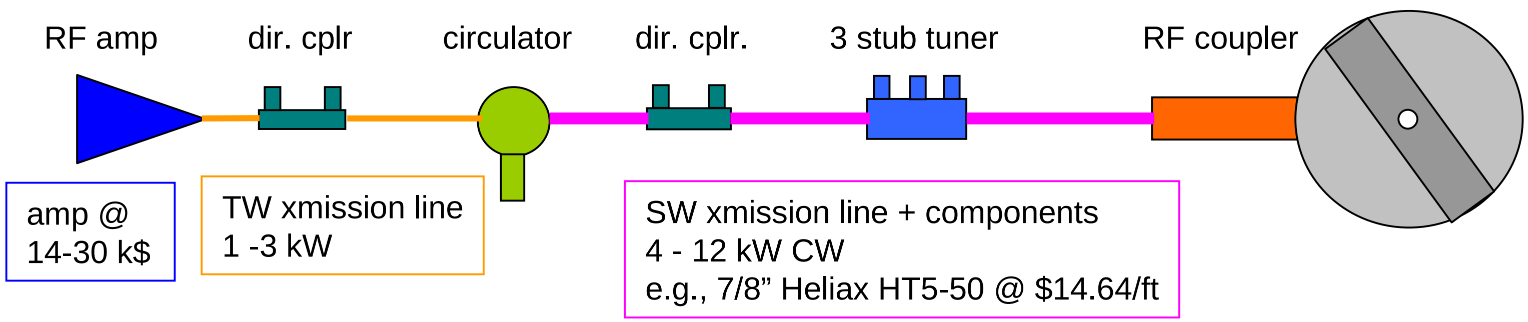
- Reduced (by stiffening) or compensated (by VCX) microphonics allows a smaller RF coupler to be used than the overcoupled case
  - for the low-β driver, the coupler is smaller by a factor of ~3 - 4
  - for the high-β driver, the factor is ~4 - 6
- In addition, the larger RF power levels for the overcoupled case impact component cost and size throughout the RF system

Strawman Low-β RF Architecture Designs for RIA

Microphonic-compensated Case



Overcoupled Case



RF Cost Data for Amplifiers, Low and High β Linacs

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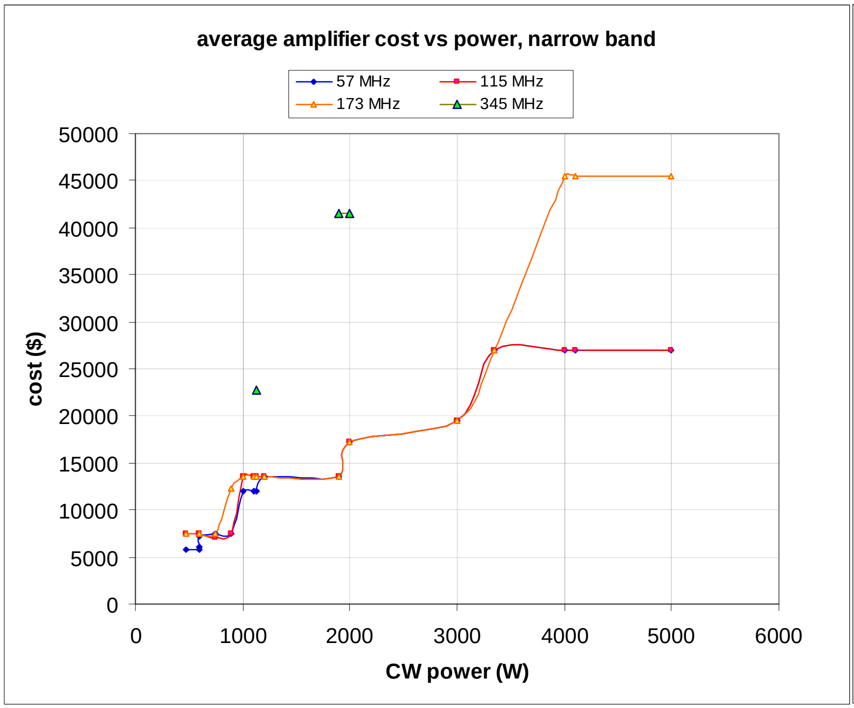
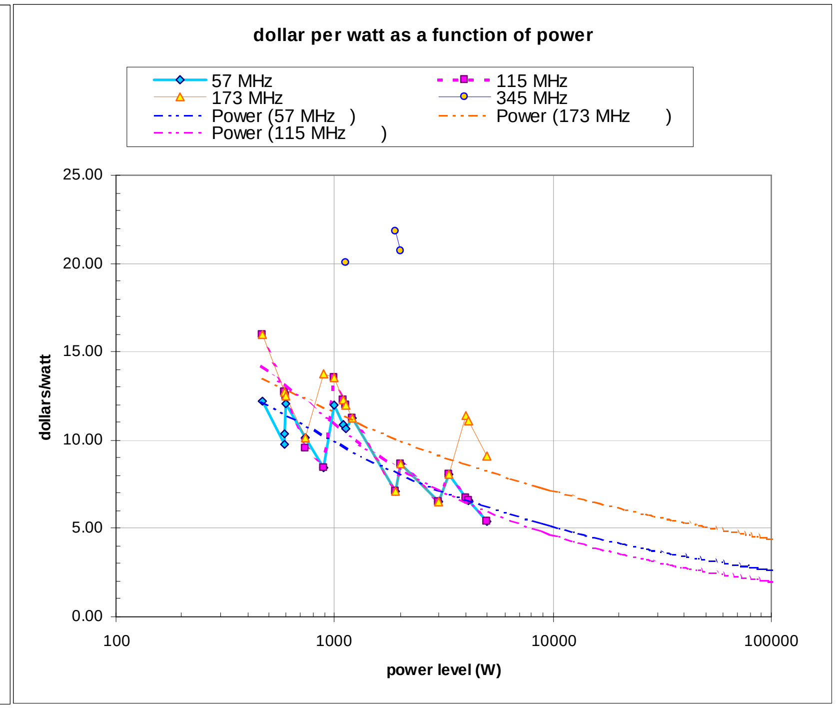
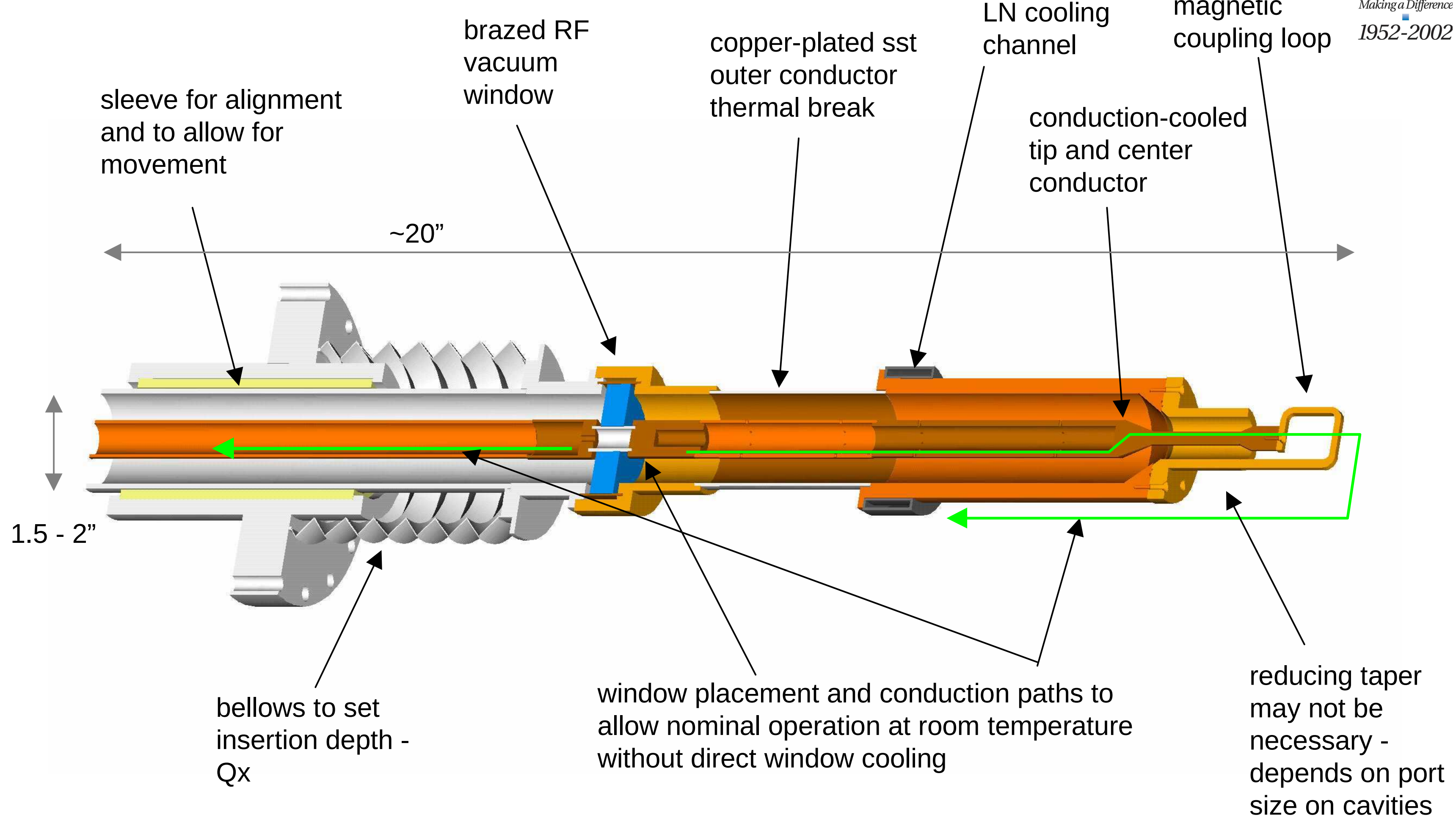




Data used to evaluate RF system costs for the low-β driver linac architectures

Extrapolated $/Watt numbers used to evaluate RF system costs for the high-β driver linac architectures

Baseline Design of an RF Coupler for the Low-β Driver Linac



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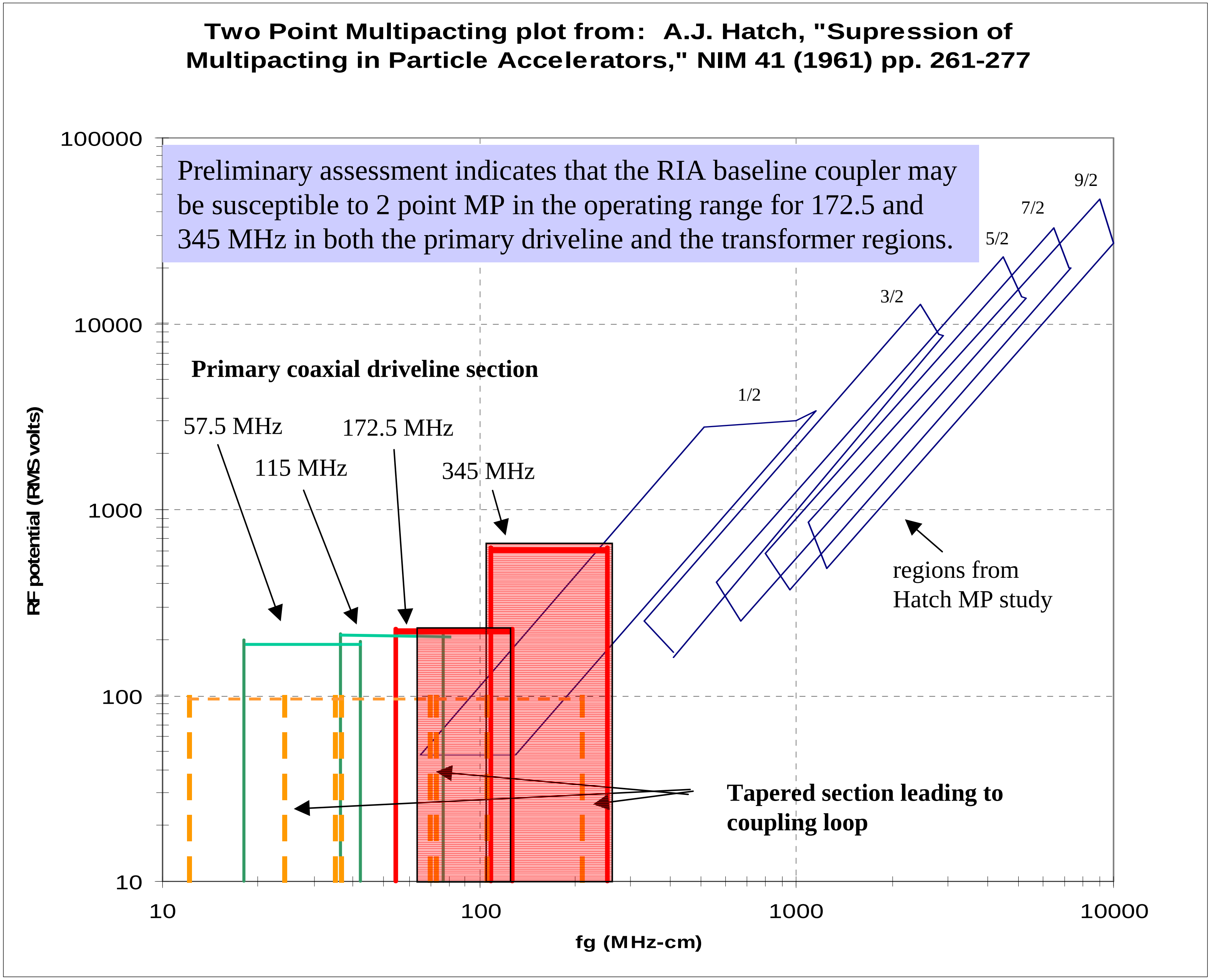
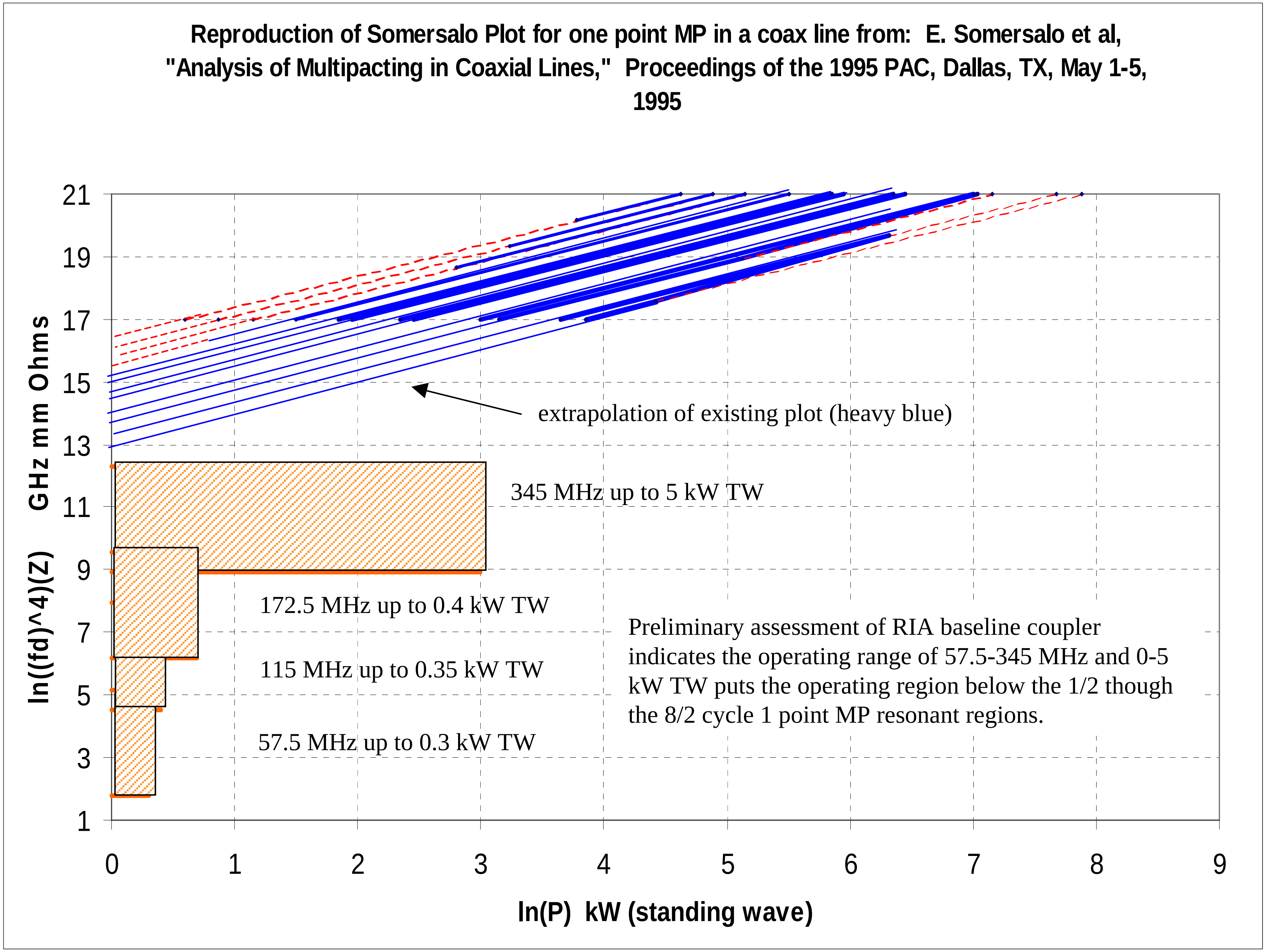
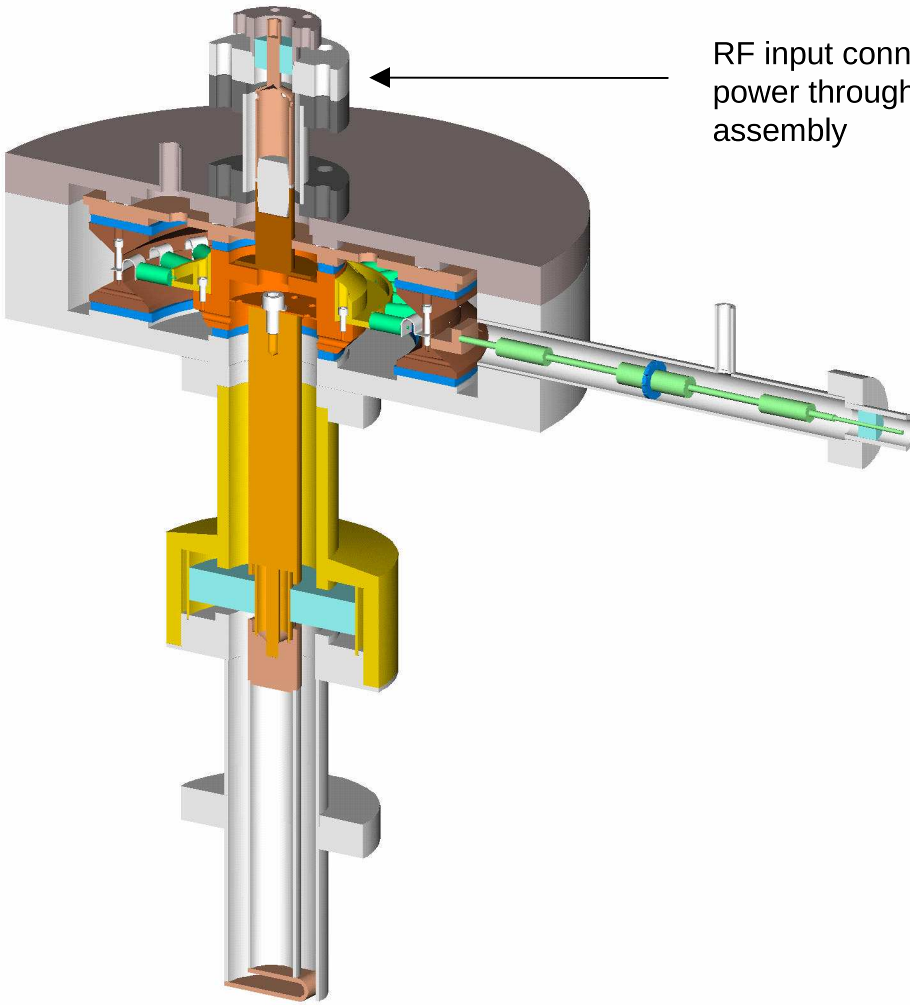

Two Point Multipacting plot from: A.J. Hatch, "Supression of Multipacting in Particle Accelerators," NIM 41 (1961) pp. 261-277
Preliminary assessment indicates that the RIA baseline coupler may be susceptible to 2 point MP in the operating range for 172.5 and 345 MHz in both the primary driveline and the transformer regions.
Primary coaxial driveline section
57.5 MHz
115 MHz
172.5 MHz
345 MHz
1/2
3/2
5/2
7/2
9/2
regions from Hatch MP study
Tapered section leading to coupling loop
RF potential (RMS volts)
fg (MHz-cm)
100000
10000
1000
100
10
10
100
1000
10000



Reproduction of Somersalo Plot for one point MP in a coax line from: E. Somersalo et al, "Analysis of Multipacting in Coaxial Lines," Proceedings of the 1995 PAC, Dallas, TX, May 1-5, 1995
ln((fd)^4)(Z) GHz mm Ohms
ln(P) kW (standing wave)
21
19
17
15
13
11
9
7
5
3
1
0
1
2
3
4
5
6
7
8
9
extrapolation of existing plot (heavy blue)
345 MHz up to 5 kW TW
172.5 MHz up to 0.4 kW TW
115 MHz up to 0.35 kW TW
57.5 MHz up to 0.3 kW TW
Preliminary assessment of RIA baseline coupler indicates the operating range of 57.5-345 MHz and 0-5 kW TW puts the operating region below the 1/2 though the 8/2 cycle 1 point MP resonant regions.

It May be Possible to Incorporate the RF Drive into the Fast Tuner Assembly



RF input connection transmitting power through the fast tuner assembly

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Open Questions (and Discussion Points) on the RIA RF Coupler

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- Since the power levels are reasonably low on RIA, is a 3 stub tuner be the best choice to achieve cost effective adjustability?
- Is making “one coupler fits all” the right approach for the low-β driver?
- What is the best common port size for the 4-6 cavities comprising the low-β driver linac? 1.5”, 2”, 2.5”...
- Is the SNS power coupler the best design for the RIA driver elliptical cavities?
  - The average power level is nominally right for TW operation (40 kW), but what about using a stub tuner, or handling mismatches?
  - Lighter beam loading will necessitate modifying the Qx set from SNS
  - How will CW vs. pulsed operation impact thermal intercept temperature choice and refrigerator efficiency?
  - Will saved NRE costs really compensate the technical compromises?